BURGDORF, JERI LYNN. The Relationship of Strength of Selected Muscle Groups to the Five Iron Driving Distance for Women Golfers. (1968) Directed by: Miss Ellen Griffin. 63 pp.

It was the purpose of this study to ascertain if there were a relationship between strength in selected muscle groups and driving distance for women golfers using a number five iron.

Thirty women were selected as subjects on the basis of their five iron driving distance in golf. The subjects were then divided into two groups; Group One contained the fifteen golfers who drove the greatest average distance, Group Two contained the fifteen golfers who drove the least average distance.

Each of the thirty subjects was given fourteen cable tensiometer strength tests. These scores were converted into T-scores and were combined to yield a total strength score for each subject in groups one and two, and a total strength score for each test.

In order to determine if there were a statistically significant difference between the strength of the high and low groups, the Fisher's "t" test of significance for small uncorrelated samples was employed. The product moment correlation technique was employed for determining the relationship within the high and low groups. In order to ascertain the difference between the correlations of the high and low groups in relation to strength, the "z" test of significance was calculated.

The findings of this study resulted in the following conclusions:

1. The high group showed significantly more strength in the shoulder area than did the low group.

2. The following were found to be significantly stronger in the high group:

A. Right shoulder adduction, which occurs during the downswing;

B. Left shoulder flexion, which occurs during the entire swing pattern;

C. Left wrist dorsal flexion, which occurs slightly at address and during the follow through;

D. Right and left shoulder flexion, extension, adduction, and abduction.

3. The statistically significant correlation of right shoulder flexion strength with driving distance for the high group seemed to indicate the importance of the entire right shoulder's movement during the swing.

4. The statistically significant correlation of the inward and outward rotation strength of both hips with driving distance seemed to indicate the importance of hip rotation strength to distance.

THE RELATIONSHIP OF STRENGTH OF SELECTED MUSCLE GROUPS TO THE FIVE IRON DRIVING DISTANCE FOR WOMEN GOLFERS

by

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APPROVAL SHEET

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INTRODUCTION AND STATEMENT OF PROBLEM

INTRODUCTION

Every golfer from time to time determines to improve his game in any of a number of ways. One such way is an exercise program based upon the theory that there is a relationship between strength and success in golf. However, there exist many varied hypotheses as to the anatomical area in which it is most important to develop strength. Studies have been done which indicate a moderate to high relationship between strength and distance in the softball throw (40,42), between shoulder strength and swimming speed (46), between over-all strength and athletic ability (27), and between leg strength and athletic ability (9).

As far as could be ascertained, there were very few studies which were devoted to determining if certain "... of the muscles which act over some portion of the driving phase of the stroke ..." (37:172) in golf had a significant relationship to driving distance. The evidence which was reviewed concerning strength in golf was related to research on grip strength (36,44,39,12). Professional golfers have contributed to the literature concerning strength, (15,16,18,19,24) however,their contributions were based on experience rather than on scientific research.

This study was designed for the purpose of ascertaining if the strength level of selected muscle groups would have an effect on women golfers with regard to their five iron driving distance in golf. The study determined the strength or force exerted against resistance (40) of selected muscle groups using three trials with the cable tensiometer as the measurement instrument (33,6,28,47). Distance was determined by hitting twenty golf balls with a number five iron (36).

STATEMENT OF PROBLEM

It was the purpose of this study to ascertain if there were a relationship between strength in selected muscle groups and driving distance for women golfers using a number five iron. An attempt was made to ascertain these relationships through the use of three statistical techniques: (1) the Fisher's "t" test of significance for small uncorrelated groups, (2) the simple correlation product moment technique, and (3) the Z test for significance of difference between the converted correlations.

The Fisher's "t" test was used to ascertain whether there was a significant difference between the strength of the high and low group in relation to the following: (1) each of the fourteen strength tests, (2) each of the three selected muscle groups, (3) total strength index for each group. Correlations were then calculated using the simple correlation product moment technique for the following:

1. Each group's driving distance with each of the fourteen strength tests.

2. Each group's driving distance with strength scores of each of the three selected muscle groups.

3. Each group's driving distance with the total strength index for each group.

Finally, the Z test for significance of difference between the converted correlations was used to ascertain whether there was a significant difference between the correlations for the high and low groups in relation to the following: (1) each of the fourteen strength tests, (2) each of the three selected muscle groups, (3) total strength index for each group.

This study was undertaken with the hope that it would aid the teacher's insight into the selection of areas for emphasis in golf instruction.

CHAPTER II

DEFINITION OF TERMS

The following definitions (21) were used in this study:

WRIST-

palmar flexion--From the anatomical position, a forward-upward movement in the sagittal plane, which pulls the palmar surface of the hand closer to the forearm's anterior surface.

dorsal flexion or hyperextension--A movement in which the posterior surface of the forearm is approached by the dorsal surface of the hand.

SHOULDER-

flexion--A forward-upward movement of the humerus.

extension--Return movement from flexion.

abduction--A sideward upward movement of the humerus.

adduction--Return movement from abduction.

HIP-

outward rotation--The rotation of the femur on the longitudinal axis, so that the knee is turned outward.

inward rotation--The rotation of the femur on the longitudinal axis, so that the knee is turned inward.

CHAPTER III

REVIEW OF LITERATURE

Professional players and instructors of golf have advocated many different methods of teaching. Inherent within this diversity were various theories concerning the anatomical area or areas upon which the prime emphasis should be placed in order to achieve, as Novak (14) stated, distance and direction. It has been noted that there is general agreement about the swing as being the movement of "... the clubhead in a swinging motion," (10:300) and since it involves co-ordinated body movements, the power which should come as a result of the swing lies in "... the ability to create speed through the use of all the muscles in the body...." (23:48) Berg (2:21) has stated that, "A properly executed swing is as fine an example of coordination and blended muscular control as you will observe in any athletic action." Williams (23:54-55) emphasized the importance of the swing by breaking it down into the contributing anatomical areas. He stated, "When a player learns to work his hands in unison with the back, shoulder, leg, and forearm muscles, he can expect to get consistently better results." Hogan (11) described the swing as the legs, hips, shoulders, arms, and hands being properly poised and interrelated to be able to move with power and coordination. Jacobs (45:1) stated, "... the component parts of a swing must all be developed to perfection and unity in order to obtain maximum results with minimum effort."

"... numerous proponents of golf believe that a single item in the total aspect of the game may be isolated, and that this one particular item may have a definite and significant influence on increased distance" (45:1). There is evidence in other sports to support that strength is one such factor. Barrow (40) has illustrated that moderate to high correlations of strength to distance in the softball throw were exhibited. Grande (42) concluded that an increase in strength could bring about an increase in the level of motor performance.

The determination of the origin of power in long distance driving has many hypothetical answers. Some professional instructors purported to increase driving distance by placing a great amount of emphasis on the strengthening and correct use of the wrists and hands during the swing. Berg (2:16) believed that the hands are the single most important factor in the golf swing, but that, "The wrists are also important for they are the hinges co-ordinating arms and hands. The wrists carry enormous power. Unless they are allowed to play their part, a great loss of distance...will occur." In agreement, Hogan (11:18-20) said,

> The player's only contact with the ball is through the clubhead, and his only direct physical contact with the club is through his hands. In the golf swing, the power is originated and generated by movements of the body. As this power builds up, it is transferred from the body to the arms, which in turn transfers it through the hands to the clubhead.

Zaharias (24) believed that the wrists put power in the golf swing. Rees (16), Player (15), and Snead (18) have written that the uncocking of the wrists is the movement upon which the swing depends. Jones and Brown (12) had reference to the legs, hips, and trunk in stating that all other parts of the body will do their respective jobs, so long as the golfer is conscious of the swinging club head as guided by the hands. The actions of these parts were considered to be responsive as opposed to being initiative of clubhead action.

Just as some professionals stressed the importance of the hands and wrists, others supported the view that the strength and correct use of the shoulders in golf would determine the successful drive. Player (15) has placed himself in this category by saying that strong male golfers are capable of hitting a long ball with little hip turn, relying primarily on better developed arm and shoulder muscles. Bell (1) and Hogan (11) concurred in their opinion that the shoulder turn was important and that the turn should go as far around as possible. Concerning the shoulders in golf, Bolstad, Griffin, and Rotvig (3) believed that the powerful muscles in the back add more power through the shoulders, and the big muscles in the shoulders and upper arms further the buildup of power by pulling the arms around.

Jones (13) and Hanley (31) advocated strong hip movement in the golf swing. Novak (14) noted that in all sports it is essential that a turning or pivotal action of the body be used to develop the force which may be imparted either through the hands or the feet. The real swing in golf said Novak, is accomplished through the body turn. To some analysts of the swing in golf, the body turn is produced by a coiling of the trunk muscles due to a full tilting and turning of the hips and shoulders. These trunk muscles when uncoiled on the downswing, give maximum power. (30) Broer (4) has stated that rotating the body lengthens the backswing giving more time to work up momentum, and also adds force to the shot since the strong trunk muscles are added to the movement. Hogan (11:71-74) analyzed the importance of the hips in the following manner:

> The downswing...is initiated by turning the hips back to the left.... This turning motion increases their tension. It is this increased tension that unwinds the upper part of the body. It unwinds the shoulders, the arms, and the hands in that order....

Clarke (7), a noted expert on strength, related that many studies (42,27) have shown muscular strength to be an essential factor in athletic success. Along the same line, Rogers (17), originator of the Rogers Physical Fitness Index, pointed toward strength as being the basis of all physical activity. Anderson (25) has found, however, in using the Roger's Physical Fitness Index that strength is not the sole factor in girls' athletic ability. She determined that speed and build may enter into their potential.

Strength is the amount of tension exerted in one single muscular contraction on some external resistance (40,22,9,17).

> The muscle is at its full strength when the oxygen intake is sufficient and when more blood cells are present in the muscle. Also when each muscle cell is strong and thereby enlarged--even though the number of cells remains the same. (26:259)

The strength of muscles in various body parts has been ascertained through the use of measurement devices. These devices had their beginning well over three centuries ago, and have been used in the United States since the end of the 19th century. Hunsicker and Donnelly (32) have stated that the dynamometer of the spring steel type has been utilized as the principle instrument for strength testing. Graham, from England, first used the dynamometer which is the oldest instrument for the measurement of strength. The first spring steel dynamometer was a crude device of 1807, made in France by Regnier. Regnier's dynamometer was improved upon by Sargeant of the United States, and with few revisions is being used today to measure back and leg strength. Other additions to the type of dynamometer which had been developed were the Kellogg Mercurial dynamometer which was based upon the hydraulic principle, the pneumatic dynamometer for measuring grip strength (32), the Martin balanced dynamometer which measured the resistive strength of an individual, and the electrical gauge dynamometer to measure both back and leg muscle strength plus maximum endurance (27).

> The spring steel, mercurial, and pneumatic dynamometers together with the cable tensiometer were designed to a single maximum effort. The [Kelso Hellebrandt] ergograph ...the electrical strain gauge dynamometer, [and the Newman myometer] were developed with the idea of securing a series of muscular efforts or for making a total record of the force from the initial movement through the drop-off (32:419).

The previously mentioned instruments have been used extensively by physical educators in an attempt to measure individual strength and ultimately to correlate the relationship of strength to motor ability. In an examination of measurement devices, the dynamometer stands out as an instrument which has had very little change of design since its introduction in the early 19th century.

> All spring steel dynamometers are based upon the same principle, namely deformation of a piece of steel either in the form of a ring, ellipse, or coil with the deformation of the metal being proportional to the force applied (32:418).

A counterpart of the spring steel dynamometer is the Kellogg mercurial dynamometer which has not been widely utilized. The utilization restriction has been partly due to its high cost and its cumbersome size. Another dynamometer, the pneumatic type, is used in the measurement of grip. Finally, the electrical gauge dynamometer, developed by Tuttle, Janney, and Salzano (30), measured the strength of the back and legs plus maximum endurance. The underlying theory of this instrument was based upon a wire which changed its electrical resistance when stretched. Forces up to 500 pounds were applied to a steel bar and registered by the movement of the fulcrum of the bar. Closely following the invention of the dynamometer was the successful research by Martin (27) in which a device called the spring balance was completed. The spring balance was used for measuring the strength of twenty-two muscle groups. In this test, a sling was fastened to the extremity with the pull at right angles to the long axis of the limb. The spring balance is attached to the opposite end of the sling. The subject contracted the muscle being tested and held it against the pull of the spring balance. The registered resistance represented the muscular strength. A third type of measurement device is the Newman myometer. This device consists of a housing cylinder which encloses the entire mechanism. Extending from one end of the cylinder is a shaft with a pressure transmitting button; a dial gauge is located at the other end. The force exerted on the button is transmitted to the gauge by a built-in hydraulic pressure converter.

> The tester pushes the transmitting button against the body part acting as a lever; the strength score is recorded at the point where the subject breaks, i.e., is unable to resist the pressure applied and gives way (30:264).

Sixty pounds is the maximum capacity of the Newman myometer. The ergograph of Kelso and Hellebrandt composed a fourth category of measurement devices. On the instrument are two counters, one records the number of movements made by the subject; the other is a distance meter which records cumulatively the total distance the subject raises the load. Six such ergographs have been designed for movements of the thumb, wrist, grip, radioulna, shoulder, and elbow (30). For the final category, Clarke adapted the use of the cable tensiometer to physical education (6). The cable tensiometer was originally designed to measure the tension of aircraft control cable. Cable tension is determined from the force needed to create offset on a riser in a cable stretched between two set points, or sectors. This tension can be converted directly into pounds on a calibration chart. Thirty-eight strength tests were designed, including: finger, thumb, forearm, elbow, shoulder, neck, trunk, hip, knee, and ankle (6). Among the devices developed for strength testing in addition to mechanical instruments have been several batteries of tests. One such battery was the 1880 strength test developed by Sargeant and used from 1880 to 1890. Frederick Rand Rogers, in 1925, developed another battery for testing physical capacity based on strength. Roger's battery was reliable with a coefficient of .86; however, the variety of expensive equipment which was required made it impractical for administration. Roger's test included the back and leg lift, right and left grips, lung capacity, chinning, and dipping (27).

In the area of strength testing devices and processes, Clarke (29) compared the effectiveness of four such instruments: cable tensiometer, Wakim-Porter strain gauge, spring scale, and Newman myometer. Objectivity coefficients determined the cable tensiometer as having the greatest precision for strength testing. The strain gauge had a satisfactory degree of precision, but proved to be more sensitive to slight tensions, such as temperature. Excess joint movement was permitted in the use of the spring scale due to pronounced stretching of the testing unit. Such movement also allowed change in the requirement of a ninety degree angle of pull for all tests. These factors reduced spring scale test scores as compared with the other three instruments. The myometer resulted in considerable testing difficulty, the objectivity coefficients being relatively low; and test scores much lower than those obtained with the tensiometer. Further results showed that the Tuttle strain gauge dynamometers had satisfactory objectivity coefficients--the back and leg dynamometer permitted testing up to a 3,000 pound pull. The Kelso-Hellebrandt ergographic instruments effected the measurement of isotonic muscular endurance (29).

A number of studies have been concerned with the use of the tensiometer, the strain gauge, the ergograph, and the myometer (27,44,43, 30). Clarke (29) performed one of the basic studies which involved a comparison of the aforementioned measurement devices. In the conclusion of his research project, Clarke (29:272) stated: "... the cable tensiometer had greatest precision for strength testing. It was the most stable and generally useful of the instruments; and was free of most of the faults of the other devices."

The tensiometer was originally used in 1945 by H. Harrison Clarke and Kjell J. Peterson who were attempting to measure the strength of muscles affected by orthopedic disabilities (27). As an instrument designed to record the tension exerted on aircraft control cable, the cable tensiometer measured the force needed to create offset on a riser in the cable between two set points or sectors. (See Appendix A) This tension may be converted into pounds on a calibration chart. (See Appendix B) Manufacturers of the tensiometer have improved upon their product for use in strength testing by special calibration for an "up-pull" on a cable rather than placement on a taut cable, and by the addition of a maximum pointer to facilitate reading the subject's score. Two types of tensiometers are generally used in strength testing. The first, for testing the strong muscle groups, is a tensiometer capable of measuring up to 400 pounds of force. This instrument, however, will not measure accurately below 30 pounds. The second type of tensiometer can test from 5 to 100 pounds, solving the 30 pounds and below accuracy problem of type one. In the administration of cable tension strength tests, a number of straps and pulling assemblies were needed. Essential to the operation of the tensiometer were the chain and snap, the regulation strap which is optional as to the type of test, the goniometer, the wall hooks, and the testing table. The chain and strap consisted of a short piece (12" to 18") of 1/16th" extra flexible cable attached to a light welded link chain (3' long). To the other end of a cable was attached a four inch double harness strap (see Appendix A). The regulation strap was constructed of webb belting, 2'6" long and 2" wide stitched around a "D" ring. A keeper was made from the same material. The goniometer was an instrument used for measuring joint angles specified for various tests. This device consisted of a 180 degree protractor with two arms of 15". One arm was stationary and extended along the zero line; the other was movable, permitting rotation to the proper angle. Into the point of rotation of the movable arm was inserted a winged nut and bolt to set specified angles (see Appendix A). The connection of the chain and strap to a stationary object was made by using wall hooks. These hooks were 4" long and withstand pulls up to 400 pounds when screwed into a solid wooden foundation. The lowest hook should be 1" from the floor; the others placed horizontally six inches apart to a height of 73 inches from the floor. The testing table was a padded table 6'6" in length, 2'9" in width, and 2'6" in height and was used for placement of the subject in correct position for most of the tests. So as to permit trunk and hip tests with their attachments being directly below the subject, a slit 20" x 7" was cut lengthwise in the table, 10" from one end. Appropriate hooks for attaching the pulling assembly were placed in a frame under the table (6).

The tensiometer, when used with the preceding instructions, has been advantageous to researchers in many studies (48,46,30,28). Hunsiker and Donnelly (32) reported the minimal size of the tensiometer to be useful in a test battery which involved testing strength of movement in a number of joints. Kennedy (33) stated that the use of the tensiometer allowed little displacement or stretch during a lift, which would mean that the subject could remain at a maximum angle of lift.

The available evidence seemed to indicate that certain areas of the body were more important to the golf swing than were others. If the strength of these areas could be mechanically ascertained, these data could aid in determining if strength is related to the distance the ball is driven with a number five iron. It could also demonstrate which area or areas should be the strongest for golf. Such knowledge could aid golfers and teachers of golf in understanding the importance of strength in the golf drive.

CHAPTER IV

PROCEDURE

This study was undertaken to test whether there was a significant correlation between strength in all three selected anatomical areas and distance a golf ball can be hit, and whether there was a significant correlation between strength in one particular selected anatomical area and the distance a golf ball can be hit using a number five iron. Due to an inadequacy of material for review on the kinesiological examination of the golf swing, and due to the necessity for this analysis as a prerequisite for the understanding of the cable tensiometer tests, it became apparent that the golf swing should be described in kinesiological terms. Based on Wells (21) definition of terms used in a muscular analysis (see Appendix C) and Crogen's (8) definitive statements of position of swing, the following was developed for use in this study:

Address Position--"Player's position of readiness before attempting to hit the ball." (8:16)

SHOULDERS: left--hyperadduction and flexion
right--hyperadduction and flexion

HIPS: left--abduction and flexion
right--abduction and flexion

SPINE: rotation on vertical axis

WRISTS: left--mid prone-supine position, slight dorsal flexion
right--mid prone-supine position

Backswing Position--"Movement from address to the top of the swing." (8:16)

SHOULDERS: left--hyperadduction and flexion
right--abduction

HIPS: left--outward rotation and flexion
right--inward rotation and flexion

SPINE: rotation on vertical axis

WRISTS: left--radial flexion, slight dorsal flexion
right--radial flexion

LEGS: left--knee flexion
right--slight knee extension

Apex--"A momentarily held position at the top of the backswing." (8:16)

Downswing--"Movement from the apex of the swing to the ball." (8:16)

Impact--"The instant at which the clubface contacts the ball." (8:16)

Follow through--"Movement which occurs after club impact." (8:16)

WRISTS: (after impact) Left--dorsiflexion
right--palmar flexion

SHOULDERS: left--abduction
right--hyperadduction and flexion

HIPS: left--inward rotation

SPINE: spinal rotation on vertical axis

LEGS: left--knee extension

In the foregoing analysis, the golfer was considered to be using a five iron and playing the ball from the center of the stance.

Selection of Subjects

The subjects for this study were women students and staff of The University of North Carolina at Greensboro and teachers in the Guilford County schools during the second semester of the 1967-68 academic year.

These subjects were suggested by the golf staff of The University of North Carolina at Greensboro. Each prospective subject was briefly introduced to the study, its purpose, and its basic procedure. She then was asked to sign for a thirty minute driving test between March 5 and March 9. Forty-eight women agreed to be subjects; of these forty-eight, forty-one were students, five were staff, and two were teachers in the Guilford County schools. The golf driving test was administered March 5 through March 9. Of the original forty-eight subjects, eighteen were eliminated leaving thirty subjects to be given the cable tensiometer strength tests. The remaining thirty subjects were placed in two groups. The fifteen persons hitting the greatest average distance were selected, as were the fifteen who hit the smallest average distance. The fifteen persons in the high group were designated as Group One, and the low group, Group Two. Group One consisted of ten students, three staff, and two teachers in the Guilford County schools. Group Two consisted of fifteen students. Of the thirty subjects composing the two groups, all thirty completed the strength test.

Selection of Tests

Two tests were selected for use. The driving distance test, used as the first test in this study, was also used in research by Purdy and Stallard (36) in which they attempted to ascertain the effect of two learning methods and two grips on the acquisition of power and accuracy in the golf swing of college women. In the Purdy-Stallard study a five iron was used in driving twenty golf balls to determine driving distance. The second selected test was a cable tensiometer strength test. The tensiometer, originated by Clarke (6) has been proven reliable and valid for strength testing. Many studies can be cited which compared the tensiometer with other strength measuring devices (29,38,30,33,32). These studies all agreed that the tensiometer, with its objectivity coefficient of .90 and above, was the most accurate and convenient form for strength testing (6). The aircraft cable tensiometer was manufactured by the Pacific Scientific Company of Los Angeles, California, and measured from five to one hundred pounds of tension induced upon a 1/16th inch cable. The tension exerted on the cable is converted to pounds by means of a conversion table. In order to test the three selected anatomical areas of the body, which were the hips, shoulders, and wrists, a total of fourteen tests were administered to each subject. Each test, with the exception of the wrists, was given with three trials for both the right and left appendages. Each of the fourteen strength tests is explained in detail under Administration of Tests.

Administration of Tests

Prior to the administration of either test, a test schedule which described available dates and times was circulated to suggested golfers for their signatures. The dates listed for the driving portion were March 5th to 9th and for the strength portion from March 15th to 20th. The time of day for each test ranged from 9 A.M. to 5:45 P.M. For both tests, subjects were asked to wear comfortable clothing to allow freedom of movement. Two assistants per half hour for the golf driving distance test were provided by graduate and undergraduate physical education majors at The University of North Carolina at Greensboro. These assistants spotted the twenty balls as they were hit onto the 150 by 35 yard field. The field was marked with tee markers set 100 feet apart and extending 150 yards from the tee. The teeing area consisted of three mats, one information card, and two tee markers. Of the three mats, one brush mat was used as the hitting surface and the other two were positioned for stance for the left and right handed golfer. Clubs consisted of a right and left handed five iron of standard size, weight, and shaft flex. Range balls of approximately 80 compression were used. The test administration time for each subject ranged from eighteen to twenty-five minutes in length and began with the following verbal instructions: "First I would like you to read the information card (Appendix D). You may adjust the mat upon which you are to stand. Be certain that each ball has been spotted before you hit the next one. Your warm-up time will begin when you hear the word 'Go'." The test administrator then walked to the location of the stop watch and thermometer and gave the command to begin the warm-up. The stop watch was set in motion and immediately the temperature was recorded along with the wind direction and the time of day. After the expiration of the three minute period for warm-up, a whistle ended the warm-up and signaled the test's beginning. If a ball was missed completely, the subject was asked to hit again. The allotted twenty balls were hit and the measurement procedure began. Each ball was marked where it settled. Archery ground quivers with flags numbered one through twenty were used. A rope was extended from the marker to the one hundred foot measuring tape stretched between each tee marker. After correct alignment, the figure was read off the tape and was recorded in feet on the data sheet (Appendix E).

The second test consisted of a thirty to thirty-five minute period in which fourteen strength tests were administered and recorded (Appendix F). Prior to the administration of the cable tensiometer tests, the weight, height, age, hand dominance, and hand dominance in golf were recorded for each subject. Also recorded were the temperature, the time, and the date. The subject's height was measured using the Lufkin Rule Company's Standard Ruler. Calculated in inches, the range was 1" to 78". The measure of weight was obtained by using a Type 1370 Temperature Compensated Spring G3865 made by Chatillon Duple Pumps, the range of which was 1 to 300 pounds. The temperature was recorded on a Precision Thermometer of Princo Thermometer and Instrument Company of Pennsylvania. A thermometer reading was recorded once before the first strength test and once immediately following the final strength test to assure constant temperature.

The cable tensiometer model T5-6007-117-00 serial number 7583 was one which had the capacity of accuracy in measuring 5 to 100 pounds of tension exerted upon a 1/16th inch cable attachment. The cable tensiometer was manufactured by the Pacific Scientific Company in Los Angeles, California, and was adapted for strength test use by the addition of a maximum tension pointer and a riser built to record "up pull." A majority of the fourteen tests were administered on a cushion top table of the following dimensions: length - 6'7½", height - 2'7", and width - 2'8½". The wooden extensions at the head of the table were 4'1" with hooks at 5" and 8" above the table. The testing table also had a 1'10" x 9" slit in the top, 11" from the bottom end. The pulling assembly consisted of a standard strap of reinforced material attached to a 1½", 14", or 23" cable (depending on test). This cable was attached to a chain of 3, 8, 11, or 13 links (depending on test). Four inch wall hooks completed the pulling assembly by serving as anchors to the chain and attachment. Two of the fourteen tests were done sitting at a table 2'3½" high, 2'11" long, and 1'7" wide. The chair was 1'5½" from seat to floor. The correct angle of pull in the tested joint is of utmost importance in isolating a particular muscle group. The goniometer was an accurate measurement instrument for this purpose. This device consisted of a 180 degree protractor with two 15" arms. One arm was stationary, the other adjustable to the proper angle from 0 to 360 degrees. Another device (Appendix A) used for accuracy and for expediency was the corner board, a device consisting of two pieces of wood at a 90 degree angle. This stable corner board was set up for the wrist tests, the upper arm assuming the same 90 degree angle as was evidenced by the corner board.

Verbal instructions to the subjects were in the form of five basic points: (1) Pull smoothly for each of the three trials per test, (2) Pull until you have exerted as much force as possible and then relax, (3) Always pull in the opposite direction from that in which the pulling assembly is attached, (4) Follow individual test instructions for the placement of individual body parts, (5) There will be three to six seconds of rest between trials and then the command "Ready, begin."

After the preceding verbal instructions were given, the following tests were administered (6):

Tensiometer test number one - Right hip inward rotation (see Appendix G)

The subject assumed a position of sitting at the end of the table, legs hanging free, with 90 degrees of flexion at the knee joint. A towel was placed under the knees for support and the arms were folded on the chest. The regulation strap was placed into position over the ankle with the chain end of the pulling assembly being attached to the wall on the side away from the right leg. Adduction and flexion of the thigh at the hip joint were prevented by bracing the upper thigh. Attention was also centered on preventing ankle eversion during the test.

Tensiometer test number two - Right hip outward rotation

The subject's position was the same as for test number one with the exception of the attachment of the pulling assembly. The assembly was attached to the wall hook on the same side as that of the limb being tested. Strap attachment and bracing remained the same for this test as for hip inward rotation.

Tensiometer test number three - Left hip inward rotation

All factors remained the same for this test as for the first test for hip inward rotation with the exception of the position of the assembly. The hook up, although it remained attached to the wall on the side away from the left leg, was attached to the opposite wall from that for the right hip.

Tensiometer test number four - Left hip outward rotation

Pulling assembly was attached to the left wall in this test. All other positioning was the same as for the right hip outward rotation.

Tensiometer test number five - Right shoulder adduction (see Appendix H)

The subject assumed a supine body position with the hips flexed and the feet flat on the table. The position of the free hand was on the chest. With the upper arm on the side tested being extended at the shoulder to 180 degrees and adducted to 110 degrees, the humerus was inwardly rotated by placing the forearm across the chest with the hand kept close. The regulation strap was placed around the humerus halfway between the shoulder joint and the elbow joint. The pulling assembly originated at the subject's head in a parallel position. By bracing at both shoulders, elevation was prevented and the subject was stabilized.

Tensiometer test number six - Right shoulder extension (see Appendix I)

The starting position of the subject was supine body with the hips and knees flexed and feet flat on the table. The free hand was resting on the chest. On the side tested, the upper arm was adducted at the shoulder to 180 degrees with shoulder flexion of 90 degrees and elbow flexion with the wrist in prone position. Attached to the hook at the subject's head, the regulation strap was placed around the humerus halfway between the shoulder and elbow joints. The bracer was responsible for preventing shoulder elevation by hand bracing. The guided elbow prevented humerus abduction.

Tensiometer test number seven - Left shoulder adduction

Left shoulder adduction was positioned and braced in the same manner as was right shoulder adduction of test five.

Tensiometer test number eight - Left shoulder extension

Left shoulder extension was positioned and braced in the same manner as was right shoulder extension of test six.

Tensiometer test number nine - Left shoulder flexion

In a supine body position the subject flexed the hips and knees with the feet resting on the table and the free hand resting on the chest. The upper arm on the side tested was adducted at the shoulder joint to 180 degrees with the shoulder flexed to 180 degrees, and the elbow at 90 degrees of flexion. With the pulling assembly hooked to the board which forms a cross piece below the subject's arm, the strap was placed around the humerus midway between the elbow and shoulder joints. The bracing was accomplished by placement of a hand on the shoulder to prevent shoulder elevation, and by maintaining the right angle with the pulling arm, through guiding the hand.

Tensiometer test number ten - Right shoulder flexion (see Appendix J)

Right shoulder flexion was positioned in the same manner as was left shoulder flexion of test nine.

Tensiometer test number eleven - Left shoulder abduction

Assuming the standard position for shoulder tests of a supine body position with the hips and knees flexed and feet resting on the table, the subject then placed her free hand on her chest. On the side tested, the upper arm was adducted and extended at the shoulder to 180 degrees with the elbow at the 90 degree angle of flexion. The forearm assumed a position of mid-prone-supine. For the comfort of the subject, and to allow for the easy passage of the cable under the back, towels were placed under the hips and shoulders. The strap was placed around the distal end of the left humerus just above the olecranon process. Prevention of the following was required of the bracer: shoulder elevation, raising of the elbow, and lateral trunk flexion. The bracer was aware of the subject turning her head to the side, as this could tend to cause flexion of the spine. The subject was braced with pressure on the shoulder and on the hand of the side tested. The pulling assembly was attached to the opposite wall of the tested side.

Tensiometer test number twelve - Right shoulder abduction (see Appendix K)

Right shoulder abduction was positioned and braced in the same manner as was the left shoulder of test eleven.

Tensiometer test number thirteen - Left wrist dorsal flexion

After a position change, from a lying to a sitting position, the subject rested her feet on the floor with the free hand bracing the wrist being tested. The upper left arm was adducted and extended at the shoulder to 180 degrees with the elbow in 90 degree flexion and the forearm attaining a mid-prone-supine position. The wrist was held in a mid-position for dorsal and palmar flexion with the forearm resting on the table. The regulation strap was extended around the palm area of the hand above the metacarpophalangeal joint. The cable attachment originated from the wall hook facing the palm of the wrist which was being tested. Bracing for dorsal flexion consisted of pressure on the lateral elbow to prevent arm abduction at the shoulder, and downward pressure on the shoulder to prevent elevation.

Tensiometer test number fourteen - Right wrist palmar flexion (see Appendix L)

The position for this test was the same as for wrist dorsal flexion.

Tests thirteen and fourteen were used only with right handed golfers. If the golfer was left handed, the administration of tests fifteen and sixteen was appropriate since the left hander would have a different wrist position at impact.

An additional temperature reading was taken at the termination of each series of tests.

Treatment of Data

For the initial tests of forty-eight subjects, the five drives which traveled the shortest distance were eliminated from any calculation. This was done to lessen individual variation. The mean distance and the range were found for each subject on the basis of her longest fifteen drives. The subjects were divided into two groups on the basis of mean driving distance. The fifteen longest hitting subjects comprised Group One and the fifteen shortest hitting subjects Group Two. The remaining eighteen subjects were eliminated from this study.

To determine whether the difference in driving distance between the groups was statistically significant, the Fisher's "t" test of significance for small uncorrelated samples (20) was calculated. The five per cent level of confidence was established as the critical level.

After the mean and standard deviations were calculated for each of the strength tests, the raw scores were then converted to T scores for standardization purposes. The Fisher "t" test of significance for small uncorrelated groups was used to ascertain whether there was a significant difference between the strength of the high and the low group in relation to the following: (1) each of the fourteen strength tests,

(2) each of the three selected muscle groups, (3) total strength index for each group. Correlations were calculated using a simple correlation product-moment technique for the following:

1. Each group's driving distance with each of the fourteen strength tests.

2. Each group's driving distance with strength scores of each of the three selected muscle groups.

3. Each group's driving distance with the total strength index for each group.

Finally, the Z test for significance of difference between the converted correlations was used to ascertain whether there was a significant difference between the correlations for the high and low groups in relation to the following:

1. Each of the fourteen strength tests.
2. Each of the three selected muscle groups.
3. Total strength index for each group.

CHAPTER V

PRESENTATION AND INTERPRETATION OF DATA

This study, conducted at The University of North Carolina at Greensboro during the second semester of the 1967-68 academic year, was designed to determine:

1. whether there was a significant difference between the strength of the high and low groups in relation to each of fourteen selected strength tests;

2. whether there was a significant difference between the strength of the high and low groups in relation to each of the three selected muscle groups;

3. whether there was a significant difference between the strength of the high and low groups in relation to the total strength index for each group;

4. whether there was a correlation between each group's driving distance with each of the fourteen strength tests;

5. whether there was a correlation between each group's driving distance with the strength scores of the three selected muscle groups;

6. whether there was a correlation between each group's driving distance with the total strength index for each group;

7. whether there was a significant difference between the correlations for the high and low groups in relation to each of the fourteen strength tests;

8. whether there was a significant difference between the correlations for the high and low groups in relation to each of the three selected muscle groups;

9. whether there was a significant difference between the correlations for the high and low groups in relation to the total strength index for each group.

Presentation of Findings

Thirty subjects were selected on the basis of their five iron driving distance in golf. The subjects were then divided into two groups; Group One contained the fifteen golfers who drove the greatest average distance, Group Two contained the fifteen golfers who drove the least average distance. Each of the thirty subjects was given fourteen cable tensiometer strength tests. These scores were converted into T-scores (see Appendix M) and were combined to yield a total strength score for each subject in groups one and two, and a total strength score for each test. The T-scores were also used to find the mean for each test and for each person in groups one and two. The mean driving score, as calculated for Group One, was 114 yards, and for Group Two was 72 yards.

In order to determine if there was a statistically significant difference between the strength of the high and low groups, the Fisher's "t" test of significance (20) for small uncorrelated samples was employed. These calculations were made for each individual strength test, for the selected muscle groups: (1) hips, (2) shoulders, and (3) wrists, and for the total strength index for each group. The results yielded a statistically significant difference of 3.2788, significant at the .01 per cent level of confidence, for the shoulder muscle group. Of the individual strength tests, three yielded statistically significant differences at the .05 per cent level of confidence. The right shoulder adduction test yielded a "t" of 2.680; the left shoulder flexion test yielded a "t" of 2.201, and the left wrist dorsal flexion test yielded a "t" of 2.1817. (See Table I)

The mean driving distance for each subject was correlated with results on each strength test, the selected muscle groups, and the total strength index. The product-moment correlation technique (20) was employed for determining the relationships within each of the two groups. There was no statistically significant correlation between driving distance and strength in the low group. A statistically significant correlation existed at the .01 per cent level of confidence between driving distance and right shoulder flexion in the high group. This correlation yielded an "r" equal to .7108. A statistically significant correlation was also found between driving distance of the high group and selected muscle group one, the hips. The correlation coefficient of .7051 was statistically significant at the .01 per cent level of confidence. (See Table II, page 33)

In order to determine the difference between the correlation of the high and low groups in relation to strength, the "Z" test of significance (20) was calculated. No "Z" calculation yielded a statistically significant difference. (See Table III, page 34)

TABLE I

SIGNIFICANCE OF DIFFERENCE BETWEEN STRENGTH
OF HIGH AND LOW GROUPS

Test	"t"
1	.7896
2	.1448
3	.3664
4	.6384
5	2.6809*
6	1.4117
7	1.1980
8	.9027
9	2.2010*
10	.6982
11	1.8530
12	1.0880
13	2.1817*
14	.6128
Group 1 (Hips)	.7207
Group 2 (Shoulders)	3.2788**
Group 3 (Wrists)	1.3487
Total	.2295

*Significant at .05% level of confidence
**Significant at .01% level of confidence

TABLE II

CORRELATION COEFFICIENTS OF DRIVING DISTANCE
WITH STRENGTH, FOR HIGH AND LOW GROUPS

Test	N = 15 High Group	r	Test	N = 15 Low Group	r
1		- .3274	1		- .0981
2		.1638	2		- .4178
3		- .2253	3		- .0955
4		.2787	4		.0543
5		.4161	5		- .4036
6		- .3199	6		.0015
7		- .0011	7		.0493
8		.0948	8		.3157
9		.0165	9		.0461
10		.7108**	10		.1309
11		- .2401	11		.0095
12		- .0430	12		- .1336
13		.1111	13		.2060
14		.1990	14		- .0432
Group 1 (Hips)		.7051**	Group 1 (Hips)		.4380
Group 2 (Shoulders)		.3935	Group 2 (Shoulders)		.2414
Group 3 (Wrists)		.1292	Group 3 (Wrists)		.1837
Total		.2739	Total		.1330

*Significant at .05% level of confidence
**Significant at .01% level of confidence

TABLE III

SIGNIFICANCE OF DIFFERENCE BETWEEN CORRELATION COEFFICIENTS OF DRIVING DISTANCE WITH STRENGTH

Test	Z
1	- .5930
2	- .6812
3	- .3308
4	.5734
5	- .0294
6	- .7964
7	.0858
8	.0578
9	.0760
10	1.0390
11	- .5783
12	- .0230
13	.0240
14	.3896
Group 1 (Hips)	1.0047
Group 2 (Shoulders)	.4117
Group 3 (Wrists)	.0022
Total	.3627

Interpretation of Findings

A statistically significant difference was found between the strength of the high and low groups in relation to three of the fourteen strength tests and one of the three selected muscle groups. The right shoulder adduction strength test yielded a statistically significant difference of 2.680, significant at the .05 per cent level of confidence. The left shoulder flexion strength test yielded a statistically significant difference of 2.201, also significant at the .05 per cent level of confidence. Each of these significant differences favored the high group. It could be hypothesized from these data that a strength differential in these areas might be an important factor in driving distance. The strength of the selected shoulder muscle groups showed a statistically significant difference between the high and low groups with a "t" equal to 3.2788, significant at the .01 per cent level of confidence. These data further substantiated the fact that shoulder strength may be a factor in driving distance. This hypothesis would agree with Jones (13) and Player (15), who distinguished the shoulders as being the most important anatomical area in the golf swing.

The correlations between the strength of each of the muscle groups and driving distance for the low group was not statistically significant. Within the framework of this study there was no significant correlation between driving distance and strength in the areas of the hip, shoulder, and wrist, or in the area of total strength. A statistically significant correlation between driving distance and strength for the high group was obtained. This correlation yielded an "r" equal to .7051 which was significant at the .01 per cent level of confidence. (See Table II, page 33) This writer hypothesized that the results of the cable tensiometer tests of hip strength were influenced by an uncontrollable variable. In order to meet Clarke's (6:27) requirement of "...padded support under the knees...," it was necessary that the subject have the lower leg very close to the testing table. This proximity of the leg to the table was conducive to a stabilization pressure against the table during the pull, and, therefore, could have caused a rise in the scores of the hip rotation tests. This variable, however, was present only during one half of the hip rotation strength tests. It seemed, therefore, that implications toward the import of hip rotation in the golf swing should remain. A statistically significant correlation existed at the .01 per cent level of confidence between driving distance and right shoulder flexion in the high group. This correlation yielded an "r" equal to .7108.

It could be assumed, due to the statistical significance of the shoulder muscle group; the statistical significance of two shoulder areas, shoulder adduction and shoulder flexion; and a statistically significant correlation between driving distance and shoulder flexion in the high group, that shoulder strength plays an integral role in the distance to which a golf ball can be driven.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This topic of study was chosen for the following purposes:

(1) to determine the mean distance to which the subjects could drive with a five iron;

(2) to determine the strength in selected anatomical areas of the subjects;

(3) to determine the importance of the strength of hip rotation to driving distance with a five iron;

(4) to determine the importance of shoulder strength to driving distance with a five iron;

(5) to determine the importance of wrist strength to driving distance with a five iron;

(6) to determine the importance of the total strength index (as measured by selected strength tests) to driving distance with a five iron.

The forty-eight women who participated in this study were students and staff of The University of North Carolina at Greensboro, or teachers in Guilford County, North Carolina. Of the original forty-eight, two groups were formed, all of whom played golf right handed. Group One consisted of the fifteen golfers whose mean driving distances were the highest of the forty-eight subjects. Group Two consisted of the fifteen golfers whose mean driving distances were the lowest of the forty-eight subjects. The remaining eighteen golfers were omitted from this study. This grouping came as a result of the driving of twenty golf balls by each subject with a number five iron; and the subsequent use of the fifteen longest drives for the determination of the means.

The cable tensiometer (6) was utilized to assess the strength of each golfer in selected muscle groups. The selected areas were: (1) hips, (2) shoulders, and (3) wrists.

The raw data were treated statistically to determine:

1. The statistical significance of difference between the strength of the high and low groups.

2. The correlation coefficients of driving distance with strength of the high and low groups.

3. The statistical significance of difference between the correlation coefficients of driving distance with strength of the high and low groups.

The following results were obtained:

1. There existed a statistically significant difference between the shoulder strength of the high and low groups.

2. There existed a statistically significant difference between right shoulder adduction strength of the high and low groups.

3. There existed a statistically significant difference between left shoulder flexion strength of the high and low groups.

4. There existed a statistically significant difference between left wrist dorsal flexion strength of the high and low groups.

5. There existed a statistically significant correlation of driving distance with the strength of right shoulder flexion for the

high group.

6. There existed a statistically significant correlation of driving distance with the strength of hip rotation for the high group.

7. There existed no statistically significant correlations of driving distance with strength for the low group.

8. There existed no statistically significant differences between correlation coefficients of driving distance with strength for the high and low groups.

The findings of this study resulted in the following conclusions:

1. The high group showed significantly more strength in the shoulder area than did the low group.

2. With reference to Wells (21), and the kinesiological description of the golf swing (See PROCEDURE), the following were found to be significantly stronger in the high group:

A. Right shoulder adduction, which occurs during the downswing;

B. Left shoulder flexion, which occurs during the entire swing pattern;

C. Left wrist dorsal flexion, which occurs slightly at address and during the follow through;

D. Right and left shoulder flexion, extension, abduction, and adduction.

3. The statistically significant correlation of right shoulder flexion strength with driving distance for the high group seemed to indicate the importance of the entire right shoulder's movement during the swing.

4. The statistically significant correlation of the inward and outward rotation strength of both hips with driving distance seemed to indicate the importance of hip rotation strength to distance.

CHAPTER VII

LIMITATIONS AND SUGGESTIONS FOR FURTHER STUDY

Certain factors delimited the conclusiveness of the findings presented in this study. These factors are listed below:

1. The age range for the subjects was from eighteen to fifty years. This wide range presented variables which could not be controlled.

2. Within the groups there was a wide range of ability as well as a wide range of past experience in golf.

3. There was the possibility of a fatigue factor in the strength testing due to the fact that a total of fourteen tensiometer tests were given.

After having completed this study, certain suggestions for further study seemed appropriate. Below are listed such suggestions as seemed required to make more conclusive the findings presented in this study, and to make more revealing any further studies related to this topic:

1. The age range of the subjects should be minimal.

2. The skill level should be ascertained by more objective means than were employed in this study. It is suggested that use be made of established handicaps and/or a pre-test in skill as well as personal data records which would include the number of years of golfing experience.

3. The use of the tensiometer for strength testing should be limited to as few tests as could be administered in completion of the strength testing requirement.

4. Testing room temperature and motivational method should be kept constant throughout the strength testing.

In the event that further study should be undertaken concerning this topic, the following are items to which the researcher should adhere in order to improve the driving test: if possible, the subjects should be allowed to use their own golf club for the test; the hitting area should consist of one large (4' x 5') textured mat, on which the golfer should stand and hit; there should be a method by which accuracy and carry or flight should be measured. This would dictate the use of lateral boundaries and the establishment of a minimum carry in order to be recorded.

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APPENDIX

APPENDIX A

Figure 1

Testing Apparatus, including Cable Tensiometer, Strap, Goniometer, and Corner Board

APPENDIX A

Figure 1

Testing Apparatus, including Cable Tensiometer, Strap, Goniometer, and Corner Board

APPENDIX B

TABLE IV

CALIBRATION CHART FOR CABLE TENSIOMETER

Instrument Reading	Tension Pounds	Instrument Reading	Tension Pounds
2	5	41	64
3	6	42	65
4	7	43	67
5	8	44	70
6	10	45	72
7	12	46	75
8	15	47	77
9	16	48	78
10	17	49	80
11	18	50	82
12	20	51	83
13	21	52	85
14	22	53	88
15	23	54	90
16	25	55	92
17	26	56	93
18	27	57	95
19	28	58	97
20	30	59	100
21	32	60	101
22	33	61	102
23	35	62	104
24	36	63	105
25	37	64	106
26	38	65	108
27	40	66	110
28	41	67	112
29	43	68	115
30	45	69	117
31	47	70	120
32	48		
33	50		
34	52		
35	55		
36	57		
37	58		
38	60		
39	61		
40	62		

APPENDIX C

MUSCULAR ANALYSIS FOR THE FOLLOWING MOVEMENTS:

WRIST--

Palmar flexion:

Stabilizers--triceps

Movers--flexor carpi ulnaris, flexor carpi radialis, palmaris longus, flexor digitorum profundus, flexor digitorum sublimis, flexor pollicis longus, abductor pollicis longus.

Dorsal flexion (4) or hyperextension (21):

Stabilizers--triceps

Movers--extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris, extensor communis digitorum, extensor pollicis longus.

SHOULDER--

Shoulder flexion:

Stabilizers--trapezius, subclavius

Movers--anterior deltoid, pectoralis major (clavicular portion), coracobrachialis, short head of biceps, infra-spinatus, teres minor.

Shoulder extension:

Stabilizers--coracobrachialis, long head of triceps, rhomboids, abdominal muscles, internal intercostals, sacrospinalis.

Movers--latissimus dorsi, pectoralis major (sternal portion), teres major, posterior deltoid, long head of triceps.

Shoulder abduction:

Stabilizers--trapezius, subclavius

Movers--middle deltoid, supraspinatus, long head of biceps, anterior deltoid, pectoralis major (clavicular portion).

Shoulder adduction:

Stabilizers--coracobrachialis, short head of biceps, long head of triceps, rhomboids, abdominal muscles, spinal extensors.

Movers--latissimus dorsi, teres major, pectoralis major (sternal portion), posterior deltoid, coracobrachialis, subscapularis, short head of biceps, long head of triceps.

HIP--

Inward rotation:

Stabilizers--abdominal muscles, spinal extensors, quadratus lumborum

Movers--tensor fasciae latae, gluteus medius (anterior fibers), gluteus minimus, adductor magnus (condyloid portion).

Outward rotation:

Stabilizers--abdominal muscles, spinal extensors, quadratus lumborum

Movers--pectineus, gluteus maximus, obturator externus, obturator internus, gemellus superior and inferior, quadratus femoris, and piriformis.

APPENDIX D

INFORMATION CARD FOR DRIVING DISTANCE TEST

1. You will have a three minute warm-up period after which a whistle will sound.

2. At the sound of the whistle, you will hit until you have stroked twenty balls. Please be certain that the spotters have marked one ball before you hit another.

3. Thank you very much. I will be contacting you in the near future.

APPENDIX E

DRIVING DATA SHEET

SCORE SHEET

(scores and information recorded during pre-test)

SUBJECT ______________________________

DATE ____________________ TIME ____________________

WEATHER ____________________ TEMPERATURE ____________________

CONDITION OF TURF WET ( ) DRY ( )

RECORDER			
Extra #1			
#2			
#3			
#4			
#5			
SHOT	DISTANCE		COMMENTS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

APPENDIX F

STRENGTH TEST DATA SHEET

INFORMATION SHEET (Information recorded preceding strength tests)

SUBJECT ______________________________

DATE ______________ AGE ______________

HEIGHT ______________ WEIGHT ______________

DOMINANT HAND ______ LEFT (   ) ______ RIGHT (   ) ______

DOMINANT HAND IN GOLF LEFT (   ) ______ RIGHT (   ) ______

TESTING AREA TEMPERATURE 1. ______ 2. ______

TIME ______ A.M. ( ) P.M. (   ) OPERATOR ______________

(Information recorded during strength tests)

#	AREA TESTED	TRIALS	TENSION-LBS.	CALIBRATED-LBS.
1	Right Hip Inward Rotation	1		
		2		
		3		
2	Right Hip Outward Rotation	1		
		2		
		3		
3	Left Hip Inward Rotation	1		
		2		
		3		
4	Left Hip Outward Rotation	1		
		2		
		3		
5	Right Shoulder Adduction	1		
		2		
		3		
6	Right Shoulder Extension	1		
		2		
		3		
7	Left Shoulder Adduction	1		
		2		
		3		
8	Left Shoulder Extension	1		
		2		
		3		

APPENDIX F (continued)

9	Left Shoulder Flexion	1		
		2		
		3		
10	Right Shoulder Flexion	1		
		2		
		3		
11	Left Shoulder Adduction	1		
		2		
		3		
12	Right Shoulder Abduction	1		
		2		
		3		
13	(right hander) Left Wrist Dorsal Flexion	1		
		2		
		3		
14	Right Wrist Palmar Flexion	1		
		2		
		3		
15	(left hander) Right Wrist Dorsal Flexion	1		
		2		
		3		
16	Left Wrist Palmar Flexion	1		
		2		
		3		

APPENDIX G

Figure 2

Right Hip Inward Rotation

APPENDIX H

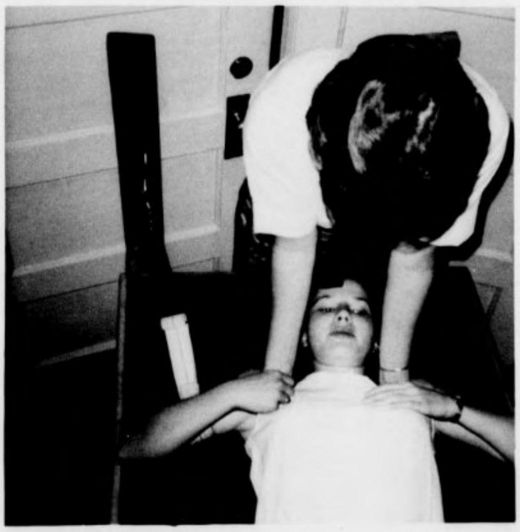

Figure 3

Right Shoulder Adduction

APPENDIX I

Figure 4

Right Shoulder Extension

APPENDIX J

Figure 5

Right Shoulder Flexion

APPENDIX K

Figure 6

Right Shoulder Abduction

APPENDIX L

Figure 7

Right Wrist Palmar Flexion

APPENDIX M

TABLE V

RAW DATA
MEANS FOR DRIVING DISTANCES, RAW* AND
T-SCORES FOR STRENGTH TESTS

Subject	Driving Distance	Rt. Hip In. Rotation	T Score	Rt. Hip Out. Rotation	T Score	Left Hip In. Rotation	T Score	Left Hip Out. Rotation	T Score	Rt. Shoulder Adduction	T Score
1	402	41	59	33	53	39	55	36	55	77	57
2	383	20	40	21	42	18	41	21	43	45	37
3	348	36	55	32	52	43	58	26	47	80	57
4	353	23	42	27	47	28	48	28	49	77	57
5	352	27	46	27	47	27	47	28	49	52	41
6	350	28	47	27	47	26	46	27	48	52	41
7	350	21	41	18	39	26	46	28	49	60	46
8	344	37	56	32	52	36	53	33	53	83	59
9	344	33	52	27	47	36	53	27	48	64	48
10	325	36	56	28	48	41	57	36	55	80	57
11	323	33	52	35	55	36	53	37	56	93	65
12	320	28	47	32	52	32	50	28	49	95	66
13	319	39	59	30	50	37	54	30	51	70	51
14	309	60	77	47	66	52	54	41	59	104	71
15	306	21	50	23	44	18	41	25	47	61	47
16	256	41	59	33	53	35	53	33	53	83	59
17	249	20	40	25	46	23	44	22	44	60	46
18	245	28	47	32	52	26	46	30	51	58	44
19	243	12	32	25	46	17	40	18	41	50	40
20	234	20	40	27	47	18	61	30	51	52	41
21	230	28	47	25	46	26	46	22	44	37	38
22	227	48	66	41	60	45	59	43	61	88	62
23	226	25	44	25	46	26	46	30	51	60	46
24	224	26	45	26	47	22	43	25	47	60	46
25	216	35	54	39	58	45	59	30	51	75	54
26	207	28	47	36	56	32	50	26	47	61	46
27	196	55	73	33	53	41	57	25	47	36	32
28	180	37	56	39	58	39	55	41	59	93	65
29	170	20	40	22	43	28	48	25	47	55	43
30	138	26	45	26	47	26	46	26	47	67	50

*Best of three trials

TABLE V (continued)

Subject	Rt. Shoulder Extension	T Score	Left Shoulder Adduction	T Score	Left Shoulder Extension	T Score	Left Shoulder Flexion	T Score	Rt. Shoulder Flexion	T Score
1	60	50	88	59	92	73	115	77	97	75
2	50	43	52	40	40	34	36	41	45	44
3	52	44	90	61	62	50	48	47	67	57
4	78	65	67	48	65	52	52	49	52	48
5	58	59	62	45	83	65	95	68	85	68
6	50	43	64	46	61	49	61	53	48	46
7	58	49	61	45	55	45	45	45	40	41
8	60	50	80	55	58	47	48	47	58	52
9	52	44	60	44	43	36	47	46	57	51
10	70	58	85	57	78	62	50	48	48	46
11	60	50	93	61	65	52	104	72	32	36
12	67	56	88	59	88	70	50	78	52	48
13	60	50	77	53	52	43	48	47	45	44
14	104	85	112	71	80	64	102	71	82	66
15	41	59	48	38	40	33	35	41	41	42
16	58	49	90	61	62	50	47	46	52	48
17	62	52	62	45	52	43	36	41	60	53
18	55	47	67	48	67	54	45	45	47	45
19	52	44	43	35	45	37	47	46	52	48
20	35	31	48	38	55	45	70	57	57	51
21	45	39	36	32	47	39	27	37	30	35
22	78	65	95	63	82	65	65	54	61	54
23	55	47	64	46	58	47	33	40	39	40
24	60	50	60	44	60	49	64	54	65	56
25	77	64	90	61	70	56	70	57	65	56
26	55	47	60	44	60	49	36	41	39	40
27	62	52	82	56	62	50	57	51	48	46
28	64	54	101	66	70	56	57	51	104	80
29	52	44	67	48	57	46	35	41	35	38
30	52	44	37	32	45	37	33	40	36	39

TABLE V (continued)

Subject	Left Shoulder Abduction	T Score	Right Shoulder Abduction	T Score	Left Wrist Dorsal Flexion	T Score	Right Wrist Palmar Flexion	T Score	Mean T Score - Total Strength
1	57	82	41	55	24	50	28	60	61.42
2	25	40	22	39	16	41	15	39	40.29
3	36	54	28	44	20	46	18	44	51.14
4	40	60	35	50	40	66	28	60	52.93
5	28	44	25	41	20	46	22	50	51.14
6	27	42	26	42	14	39	17	42	45.07
7	35	53	20	37	32	58	27	58	46.57
8	36	54	45	59	24	50	22	50	52.64
9	37	56	37	52	34	60	23	52	49.21
10	35	53	27	43	32	58	22	50	53.43
11	25	40	27	43	42	68	30	63	54.71
12	37	56	47	61	20	46	26	56	56.71
13	36	54	41	55	32	58	10	31	50.00
14	41	61	57	69	54	81	40	79	70.29
15	27	42	21	38	16	41	12	34	42.64
16	39	58	39	54	20	46	22	50	52.79
17	21	34	41	55	16	41	17	42	44.71
18	37	56	52	65	16	41	18	44	48.93
19	33	50	40	55	16	41	15	39	42.43
20	28	44	30	46	20	46	18	44	45.86
21	25	40	20	37	24	50	18	44	41.00
22	36	54	37	52	32	58	26	56	59.21
23	22	36	20	37	16	41	17	42	43.50
24	25	40	33	48	14	39	21	49	46.93
25	33	50	52	65	24	50	28	60	56.79
26	33	50	33	48	12	37	17	42	46.00
27	33	50	39	54	32	58	30	63	53.00
28	45	66	47	61	30	56	28	60	60.21
29	27	42	28	44	20	46	17	42	43.71
30	26	41	33	48	18	43	26	56	43.93

APPENDIX N

TABLE VI

STRENGTH TEST MEANS AND STANDARD DEVIATIONS

Test	Mean	Standard Deviation
Right Hip Inward Rotation	31.07	10.60
Right Hip Outward Rotation	29.77	10.94
Left Hip Inward Rotation	31.47	14.33
Left Hip Outward Rotation	29.23	12.54
Right Shoulder Adduction	67.60	17.19
Right Shoulder Extension	59.40	12.72
Left Shoulder Adduction	70.97	19.23
Left Shoulder Extension	61.97	13.29
Left Shoulder Flexion	55.27	22.19
Right Shoulder Flexion	54.97	16.74
Left Shoulder Abduction	32.83	7.54
Right Shoulder Abduction	34.77	11.40
Left Wrist Dorsal Flexion	24.33	9.65
Right Wrist Palmar Flexion	21.93	6.33